THE NEW MOVEMENT AMONG PHYSICS TEACHERS

CIRCULAR V

In response to the suggestions and questions in Circulars III and IV, 164 answers have been received. These have come from 105 secondary schools, 7 normal schools, and 52 colleges. Of these 164 answers, 43 merely expressed general approval of the work, and 24 more asked to have the remainder of the syllabus sent to them when it was ready. There were 42 who answered all of the four questions at the end of Circular IV. Of the remaining 55 letters each discussed one or more of the various points suggested.

I. Taking up first the theses in Circular III, 14 approved of them *in toto,* just as they stand; and 18 others approved of them in general, but each made a few specific suggestions as to desirable changes. In the light of the suggestions that have been received, the theses have been reworded, an eleventh added, and they are now again submitted to the teachers for criticism and suggestion in the following form:

1. The subject-matter of the present elementary course in physics must be reduced to two-thirds of its present amount, unless the time allowed for covering it be increased to one and one-half years.

2. If the subject-matter is reduced, those topics that have the least bearing on the student's life and on the problems likely to occur to him spontaneously from his own experiences should be eliminated first. The better-established portions of the subject should have precedence over the more recent unproved speculations, on the ground that, in the limited time, it is better to teach those things that will probably be still believed when the youngster is grown up.

3. In the elementary course the method of presentation is far more important than the amount of subject-matter learned. This method should be so framed that the emphasis is laid on the development of habits of scientific thought, rather than on the mastery of subject-matter. Hence it is better to present a few topics in such a manner that they are powerful examples of the method by which science obtains its results, than to try to teach a large number of more or less scattered facts and theories in such a way that they can only be committed to memory.

4. In applying practically the principle of thesis 3, it is important that definitions be justified before they are introduced. In order to do this, the concepts with which a definition deals should be built up in the student's mind by a discussion of familiar experiences, and he should be led to see that there exists among the concepts a relation that admits of definition, before the definition is stated. A definition that has been so introduced will be appreciated as a convenience and every one that is not so appreciated had better be omitted from the required work.

5. In like manner, it is generally not advisable to state a law until the concepts and relations with which it deals have been implanted in the student's mind by a discussion of common experiences and of simple qualitative demonstrational experiments. In other words, the student will generally not appreciate the law unless he be given an intuitive and qualitative perception of the relations summarized by the law before the law is stated; i. e., the law should be to him a hypothesis before it becomes a law.

6. The student should be made to see clearly that the laboratory experiments furnish the means of converting hypotheses into laws. He should also be made to see that the apparatus is not the law, that it is not necessary to remember the details of the apparatus in order to appreciate the law, and that the exemplifications of the law are not confined to the apparatus.

7. The student should be made to comprehend that every law is a tested hypothesis, and that the tests are always subject to some error, so that the statement of the law is always a statement of what we believe to be true in an ideal case. He should understand that the measurements by which a law is said to be established give results which approach more and more nearly to the law, the more carefully the measurements are made, and the more completely the disturbing effects are eliminated. He should also be shown that in every practical case the law is not verified unless allowance is made for friction, air resistance, etc.

8. In the laboratory work it is often more profitable to place the emphasis on the determination of efficiency rather than on the verification of laws. This sort of work shows clearly the practical use of the experiment, prevents false notions of the mechanical advantage of machines, helps to make clear the importance of this concept in the world's work, and tends to develop in the student a hearty respect for the value of quantitative knowledge.

9. As few units as possible should be employed, and they should be introduced only when a necessity for their use appears; i. e., they should be justified in advance as in the case of definitions and laws. By this thesis the more abstract units, like the dyne and the erg, would no longer be required in the elementary work.

10. Examinations and quizzes should be framed to test the student's comprehension of and ability to use the more important principles of physics. The questions should not ask for mere statements of the laws from memory, unless they also ask either for the arguments by which the laws are estab-

lished, or for information concerning the way in which the principle is applied in daily life. These questions should not contain complicated arithmetical puzzles of the sort that never occur in practical work, but should contain simple problems, which deal with immediate concrete applications of the principles, and which are of the kind likely to be met with outside of the classroom or laboratory. They should not demand descriptions of laboratory apparatus nor of facts which have no immediate bearing on the general principles required by the syllabus.

11. The distinction between the real facts, which are mattters of definite knowledge, and the supposed facts, which are derived from pure speculation, should be kept clear in the student's mind. For example, he should know that he is speculating when he explains the properties of gases in terms of the hypothetical molecules of the gas, and that he is dealing with definite knowledge when he describes those properties in knowable factors, like volume, pressure, density, and temperature. He should be trained to know what the things about him can do, rather than to think that he knows why they do it, because he has learned to repeat the beliefs of others concerning the modus operandi.

II. The following comments were called forth by the preamble to the definition of the unit in Circular IV:

Interest is not a necessary forerunner of knowledge (1). The ideas of force and of moments are better than that of energy as the central concepts (1). The scientific method is confused with induction (1). Too much historical physics is bad; on review, the student can be made to look up encyclopedias (1). Much more history is needed (4). On this point it seems desirable to quote a few sentences from one of the letters received, as follows: "It has long seemed to me that one serious defect of the teaching of science in our schools and colleges has been the apparent isolation of the subject-matter taught from the ordinary concerns of life. One way to remedy this defect is to provide carefully prepared courses in the history of each science and to teach these courses in connection with the courses in science themselves. In this way, the part that science has played in the development of our civilization, and all that it means to the world today, would be brought home to the pupils. Such a result could hardly fail to be a stimulus to the patient and serious study of the science of physics."

III. Concerning the definition of the unit, the following criticisms and suggestions were received:

One demands that the required time of the course be increased to 280 periods, while 10 declare 240 periods too much. Four want to see the requirement of lecture demonstration work emphasized more, 4 want all the laboratory experiments written up, and 4 more object to seeing the attempted determination of physical constants in the laboratory discouraged. Opinions

differ as to the number of laboratory experiments to be required. Four want 40; 1, 36; 2 think 35 enough; 7 unite on 30; and 3 ask for a requirement of only 20.

Some emphatic opinions were sent in with regard to the question of allowing part of the required laboratory work to be qualitative. In 6 letters the permission of qualitative experiments is hailed with delight, while in 4 others it is condemned in a no less decided way. One suggests that physics be taught in the natural history style, leaving the mathematical parts to the mathematics teacher, and another insists that the greatest value of the physics course lies in making clear the worth of definite quantitative knowledge.

In reply to question 1—namely, Does the definition of the unit seem to be what is needed?—34 out of 42 answered in the affirmative, and 8 made some suggestions as to changes.

Question 4—namely, Is the plan of starring topics more satisfactory than that of a list of experiments?—received 35 affirmative votes, and 2 negative. Two stated that it was a matter of indifference, 2 suggested using both, and 1 wished to have neither.

In consideration of the fact that the definition specifies only the minimum amount of work that will be accepted as a unit, and in the light of the suggestions received, this definition has been slightly altered and is again submitted for criticism as follows:

REVISED DEFINITION OF THE UNIT

1. The unit in physics consists of at least 200 periods of 45 minutes each (= 150 hours) of assigned work. Two periods of laboratory work count as one of assigned work.

2. The work shall consist of three closely related parts, namely, class-work, lecture demonstration work, and laboratory work. At least one-third of the time shall be devoted to the laboratory work.

3. It is very essential that double periods be arranged for the laboratory work.

4. The class-work shall include the study of at least one standard text.

5. In the laboratory each student shall perform at least thirty individual experiments, and keep a careful notebook record of them. Twenty of these experiments must be quantitative; each of these must illustrate an important physical principle which is one of the starred topics in the syllabus, and no two must illustrate the same principle.

6. In the class-work the student must be drilled to an understanding of the use of the general principles which make up the required syllabus. He must be able to apply these principles intelligently to the solution of simple, practical, concrete problems.

7. Examinations will be framed to test the student's understanding of

and ability to use the general principles in the required syllabus, as indicated in paragraph 6.

8. The teacher is not expected to follow the order of topics in the required syllabus unless he wishes to do so.

In explanation of the term "required syllabus," the commission voted at its meeting in New York to separate the proposed syllabus into two parts, one giving merely the principles required as a minimum amount of work, and the other an expanded and suggestive syllabus similar to that submitted in Circular IV. It is to the former of these that the term "required syllabus" refers.

In reply to question 2 of Circular IV—namely, is the form of the syllabus satisfactory?—1 negative and 35 affirmative votes were received. Five objected to having any syllabus at all.

Question 3—namely, Do you wish to have either the choice of subject-matter or its arrangement in the syllabus altered?—received 24 ayes and 18 nays. Those who want changes made have sent in a large number of valuable suggestions, and these will be submitted to the commission as soon as possible. In consideration of the marked differences of opinion that have appeared respecting the syllabus, the commission has decided to withhold the publication of the remainder of it, awaiting the results of a discussion now in progress in the commission. Those who have sent requests for the new syllabus will receive it as soon as it is ready for distribution.

IV. The suggestion in Circular IV, that there be introduced into the first year of the high-school curriculum an elementary course in general science, including some physics, has called forth some decided opinions. Three oppose the idea on the ground that it would take the edge off the real course in physics which comes later, and 4 others declare the proposition impractical because of the impossibility of getting the requisite time. Two claim that it has been tried in their schools and found harmful and 1 thinks that such a course belongs in the grades. One says that it should be required physiography. Four express the conviction that such a course should be worked up, 4 report having tried it with marked success, and 3 hope that such a course will be introduced in order that all the pupils in secondary schools may get at least a taste of science. (This latter in consideration of the fact that about 50 per cent. of those who enter the high schools drop out by the end of the second year.)

V. Since issuing the last circular, the commission has held two meetings, one in Chicago on November 30, and one in

New York on December 29. At the first of these meetings the question of the influence of examining boards on the teaching of physics was discussed. This discussion is still in progress in the commission, and the results of it will be announced as soon as they have been reached.

At the New York meeting two important matters were discussed: one, the form and content of the proposed syllabus; and the other, the nature of the problem before the commission. In regard to the first of these questions, the commission voted to prepare a double syllabus: one, to be very brief and to include only the principles required as a minimum of work for the unit; the other, an extended syllabus, intended to be suggestive, somewhat like that in Circular IV. In the first syllabus the attitude of the teacher toward each principle may be defined by several leading questions. The commission is now at work on these outlines.

In regard to the second question it was unanimously agreed that the commission stands for a maximum degree of freedom for the teacher; that its work lies in the direction of discussing and making clear the principles that may guide the teacher, and in supplying suggestions that may assist him in making his work stronger; that the teacher should be at liberty to apply the principles as outlined by the commission in the way he thinks best, and, in particular, he should be left in complete freedom in the choice of the tools with which he works. For these reasons the commission agreed to exclude entirely from its discussions all questions relating to the merits of particular texts, manuals, or apparatus. It is important that everyone should clearly understand that the work of the commission lies in the direction of solving an important educational problem, and that this work is to remain wholly free from implication in any way with books or with apparatus.

VI. On counting up the letters received by the commission during the past year, it appears that suggestions and criticisms have been received from 418 different teachers. Of these, 270 are in secondary schools, 113 in colleges, and 35 in normal schools. Every state in the Union has a representative among

this number, excepting Delaware, Florida, Idaho, Arkansas, and Nevada. Yet the only conclusion that all can agree to draw from the summaries of the answers as printed in the various circulars is that we teachers are far from united on any one point. Some insist on the introduction into the laboratory of a large amount of qualitative work; others are equally insistant that this work should all be quantitative. Some want to emphasize the ideas of energy; others prefer to base the work on concepts of force. Some approve of making the course strongly inductive, and of trying to teach scientific method of thought; others declare this method useless, and insist on mastery of subject-matter. Some declare that the course should be limited to pure science; others believe in making it more practical. Some wish to introduce more mathematics; others want to teach in the natural-history style entirely; etc.

Under these conditions, it seems fair to ask whether the reason for these wide diversities of opinion is not this, that we are trying to do too many things in the one year allotted to physics. If too much is expected of this one year's work, one teacher will emphasize one phase, another will cling to another, and there never can be even approximate agreement. It therefore seems plausible to adopt, as a working hypothesis which shall bring these discordant observations into harmony, the one just suggested—namely, that we are trying to accomplish too many different things in this one year. The aims of the course are at present too diffuse to be clearly grasped by anyone.

If we are willing to adopt this working hypothesis, a solution of the difficulty at once appears. This solution was suggested in one of the letters recently sent in, and is briefly this: that the teaching of physics must not be crowded into one poor year in the secondary school, but must be done partly in the grades in connection with the nature-study work, partly in a first year of general science in the high school, and partly in the special physics course in the later years of the high school, to be continued as far as desired in college. These successive bits must not overlap in such a way as to give the student the impression of going over the same ground in the same way, as is at

present the case. It therefore seems clear that the commission cannot ever reach a satisfactory solution of the problem before it, until it has discussed the entire question of the education of the child in physics in all grades.

Numerous efforts at earlier work in physics have been made in various schools during the past few years; the first step in the investigation is, therefore, to try to find out what work has already been done, and what success has been attained. You are therefore invited to contribute to this investigation by sending answers to any or to all of the following questions:

1. Has your school ever attempted to give a first year's work in general science? If so, what success was attained? What outline was used? What was the aim of the course? Where can the text or the outline used be obtained?

2. Do you think a well co-ordinated four-year course in science is desirable in the high-school, the first year to be of the general science type and required, the rest to be elective? This does not mean that there be a year in each of the separate sciences, but that at least the first year's work be in general science—a combination of several.

3. Can you suggest a series of steps in the method of presenting science—steps by which it would be possible to pass gradually from the nature-study methods of the grades to the abstract methods of the college? In what years in the curriculum should the successive steps be taken? This amounts to asking for a brief statement of the differences in the ways in which you would present science to a child of about ten, to one of fourteen, and to one of eighteen or twenty.

4. Have you any further criticisms or suggestions concerning the eleven theses?

5. Have you any further criticisms or suggestions about the definition of the unit as printed?

6. Would it strengthen the teaching of physics, if there were introduced a system of state certification of high-school teachers similar to that for elementary teachers? If so, what would you suggest as the minimum requirement for a certificate that would entitle the holder to teach physics in the high school?

Since sending out the last circular other associations have added representatives to the commission as follows:

The New England Association of Colleges and Preparatory Schools, E. H. Hall, Harvard University, Cambridge, Mass. The Association of Colleges and Preparatory Schools of the Southern States, C. A. Perkins, University of Tennessee, Knoxville, Tenn. The Northeastern Ohio Association of Science and Mathematics Teachers, F. T. Jones, University School,

Cleveland; G. R. Twiss, Central High School, Cleveland; C. H. Burr, Oberlin Academy, Oberlin. The North Dakota Association of Science and Mathematics Teachers, E. Burch, President of the State Science School, Wahpeton; Miss D. C. Jensen, High School, Fargo; C. C. Schmidt, Superintendent of Schools, Jamestown. The New York State Science Teachers Association has increased its committee by the addition of E. W. Wetmore, State Normal College, Albany; L. E. Jenks, High School, Ogdensburg.

This circular is being sent once more to all the addresses we have. Any further documents that may be issued will be sent only to those who respond in some way to this one. Back numbers of the circulars may be had on application, in case any have been lost in the mail. Since a number have suggested that more discussion would be possible if more time were allowed for the answers, the date for their final return is set as June 1. As before, they should be sent to C. R. MANN, UNIVERSITY OF CHICAGO.